



Turtle nets at Great Meadows National Wildlife Refuge by Cherrie Corey

Environmental Inventory & Analysis

Concord's wealth of natural resources has been well documented since the writings of Henry David Thoreau in the mid-nineteenth century. Since then there has been suburban development of agricultural land and industrial contamination, while at the same time also permanent protection of some of the Town's most prized natural areas has been realized. This section provides detailed inventory and analysis of the environmental resources in Concord today.

A) Geology, Topography, and Soils

Concord's topography ranges in elevation from a low of 112 feet where the Concord River flows into Carlisle, to 365-foot-high Annursnac Hill in the northwest. Several scattered hills and low ridges can be seen from many places in town, and provide a range of microclimates and habitats. Large, flat, low wetland areas provide varied wildlife habitat that supports biodiversity. The natural land surface displays a fine-scale pattern of small ridges, valleys, hillocks, and depressions. This surface is basically a result of three factors: (a) the buried bedrock surface (with faults and ice carving); (b) deposition layers of glacial till and delta sand and gravel; and (c) subsequent swamp- and river-floodplain deposits.

One billion years ago, the crust of earth that Concord occupies today would have been part of an earlier African continent.^{7, 62} Some bumping together of the former African and North American continents, mainly during the Paleozoic Era, produced high mountains, which eventually became the Appalachians. Beginning about 225 million years ago (in the Mesozoic Era), the

continents drifted apart. Much later, beginning about one million years ago (the Pleistocene Era) continental glaciers advanced, retreated, and re-advanced in the Concord area. Melting caused the southern edge of the last (Wisconsin) glaciation to retreat northward some 10,000 years ago.

When the southern edge of the last melting glacier stood just south of today's Concord Center, an extensive lake, Glacial Lake Sudbury, covered the southern portion of today's Town extending well into the Town of Sudbury. Somewhat later, with the ice edge standing in northern Concord, Glacial Lake Sudbury was south of Emerson's Cliff along today's Lincoln line. With further melting, the glacial edge had moved to the northern part of Concord and the land there was 50 feet below the delta which marked the edge of Lake Sudbury. The melting waters now backed up and began to form a new body, Lake Concord, which extended down into what is now Bedford and discharged into what became the Shawsheen River Valley. Today's Great Meadows National Wildlife Refuge, located at what was the northwest shore of Glacial Lake

Concord, was one of the last areas of the lake to drain. The large wetland there lies over the Assabet River fault. As the ice edge retreated northward, the Concord, Assabet, and Sudbury Rivers began flowing northward toward today's Merrimac River Valley, which thus drained the two glacial lakes, and caused the Mill Brook to flow westward.³² Since then, except for the Elm Brook area, almost all town land drains to the Sudbury and Concord Rivers (see Water Resources Map).

Several distinctive glacial deposits form the geomorphology of Concord.^{7, 62} Drumlins, land shaped like an inverted spoon, are thick deposits of glacial till (e.g., Punkatasset, Pine, and Nashawtuc Hills). Eskers are long, high, narrow, and sinuous sandy ridges (e.g., the ridge parallel to Monument Street and across the Concord River from Great Meadows, and the eastern sides of the Concord Country Club and Mink Pond). Kettle holes are steep-sided basin-shaped depressions (with no stream entering or leaving). If deep enough to reach below the water table, these are kettle ponds (e.g., Walden, Goose, and White Ponds). Some vernal pools (see Wildlife and Plant Habitat Map) are kettle ponds that dry out during part of the year. Kames, almost the inverse of kettle holes, appear as knobs that often separate kettle holes (e.g., Jennie Dugan Kames in south-central part of the Concord Country Club). Post-glacial lake and swamp deposits today appear as low, flat surfaces (e.g., the marsh north of Alcott School and the fields opposite Meriam's Corner, which were a part of Lake Concord).

The ridgeline north of White Pond that runs across Paul Revere Road and through Rolling Wood Lane is an ice-contact face where the glacier stopped its retreat and built up a delta while discharging its meltwaters out over the Nine Acre Corner area into Glacial Lake Sudbury. This contact face extends further over to the site of Concord Carlisle High School, the Hapgood Wright Town Forest, and towards Sandy Pond Road.

Due to differences in substrate types, vegetation types, groundwater conditions, microclimate, and land-use history, Concord has a rich mosaic of soils (see Soils Map). Several dozen named soil types are present and their characteristics further differ according to topographic slope.⁶⁹

Extensive areas of wet soils characterize this Town of three rivers. Hydric soils and soils with seasonally high water tables have been used for pastureland or conservation. Some of the latter soils also contain a restrictive hard layer that tends to prevent water from percolating downward. Most hydric soils in Town are

Bedrock Geology

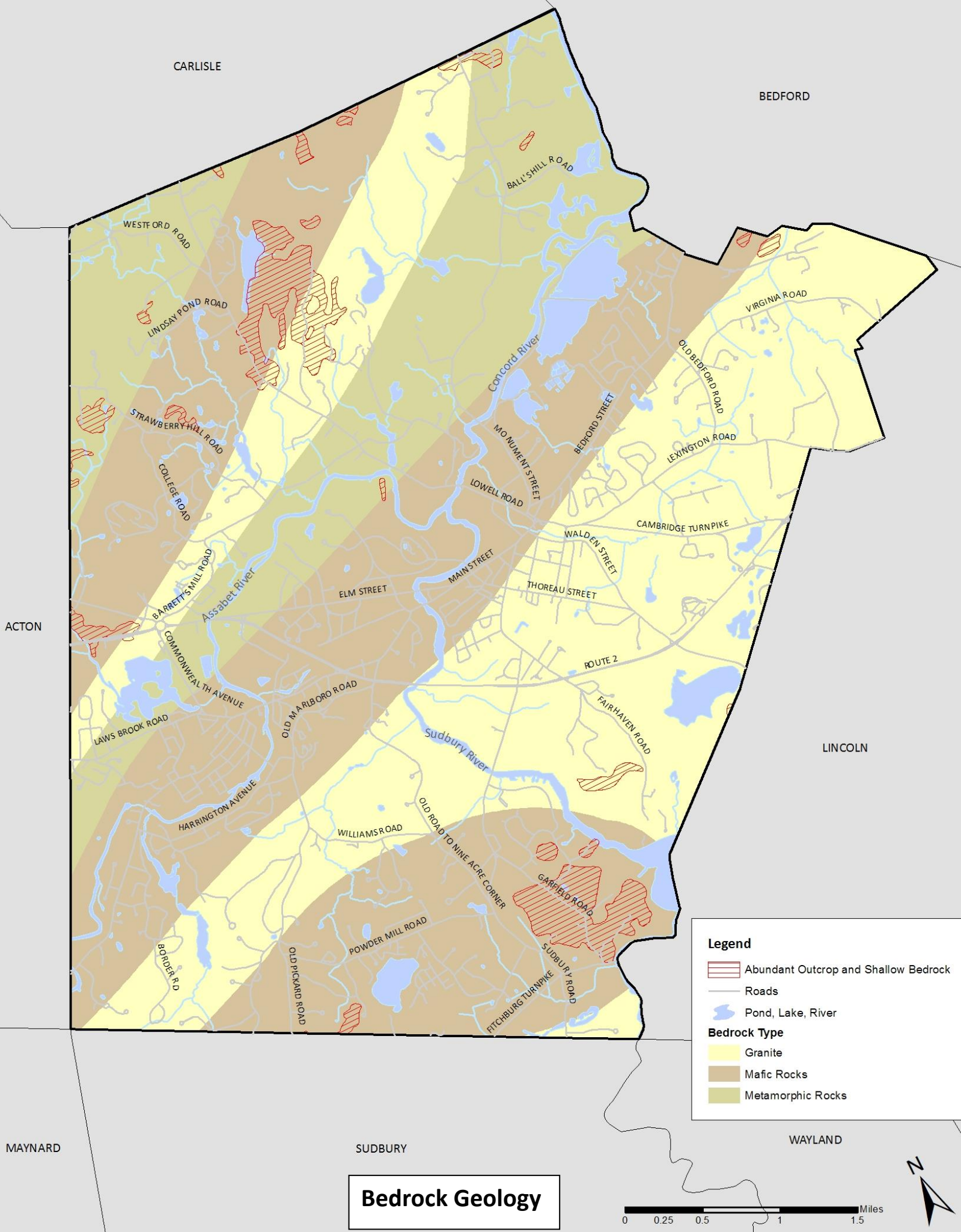
The bedrock of the Concord area is largely granitic and metamorphic gneiss. Most of the Town lies between two regionally important geologic faults, the Bloody Bluff fault to the south and east, and the Assabet River (or Clinton-Newbury) fault to the north and west. These buried fault zones give Concord its general northeast-southwest topography. Rock outcrops, where bedrock reaches the land surface, are scarce in Town. Examples include Andover granite (Fairhaven Hill, and Emerson's Cliff in Lincoln), Shawsheen gneiss (along Route 2 just east of Crosby's Corner in Lincoln), Assabet quartz diorite (near the former Buttrick Mansion and on Lowell Road, west of the river), and gabbrodiorite (west of Fairhaven Bay). A small band of marble nearly reaches the natural land surface in Estabrook Woods.

mucks, especially Freetown, Saco (mucky silt loam), and Swansea. Most soils with seasonal high water tables are loamy sand (e.g., Deerfield) or fine sandy loam (e.g., Merrimac). Seasonal high water table soils with a restrictive layer are overwhelmingly fine sandy loams, mostly of the Montauk, Paxton, and Birchwood soil types.

In contrast, Concord's well-drained soils are especially appropriate for cultivation and for supporting development such as buildings and roads. Most of the well-drained soils are loamy sand (Windsor), fine sandy loam (Merrimac), or of the Merrimac-Urban Land Complex. Additionally, there are some areas that have excessively drained soils. Several areas of Town have only a thin covering of soil over bedrock, with soils mostly of the Charlton-Hollis-Rock outcrop complex. For building construction, the soils have the following conditions, though much variation exists: severely unfavorable (hydric, Deerfield, Hollis); unfavorable (Montauk, Paxton, Birchwood, Charlton); and favorable (Merrimac, Windsor).⁶⁹ Similarly, conditions for successful septic systems tend to be: severely unfavorable (hydric, Deerfield, Montauk, Paxton, Birchwood, Windsor, Hollis) and unfavorable (Merrimac, Charlton). In Concord, surface soils have a localized effect on access to drinking water (e.g., Hugh Cargill well), soil erosion (occasional steep slope by a pond), and recreational opportunities (trail inaccessible due to high water table).

B) Landscape Character

An integrated network of large natural areas or patch-



es, large agricultural areas, major wildlife corridors, water bodies and adjacent land, and certain unique features and microenvironments contribute to Concord's special character.

For the purpose of this plan, large natural areas are defined as patches of relatively natural vegetation that are intact and wide enough to provide a large interior area of forest or wetland (i.e., remote from edge effects and anthropogenic influences). The distance between these patches is less than the dispersal distance of key species, allowing for genetic dispersal between populations. These patches maintain many combinations of natural habitat conditions in proximity for species requiring two or more habitats. The size of the patch is sufficient to support large-home-range vertebrates and many interior species, to protect an aquifer and/or headwaters network of small streams, and for most natural disturbances to affect only a portion of the patch. Three large patches may be required to maintain the total richness of native species in an area. In the 2004 and 1992 OSRP, seven such areas were identified in Town. The boundaries of these areas have been modified for this Plan and two new areas were created based on Biomap2 released in 2012 (see Open Space Framework Map and Appendix C).

Large Natural Areas:

- N1. Estabrook Woods Area**
- N2. Great Meadows / Ball's Hill Area**
- N3. Walden Woods / Town Forest**
- N4. Second Division Brook Area**
- N5. Virginia Road Woods**
- N6. Annursnac Hill / Strawberry Hill Road**
- N7. Jennie Dugan Kames**
- N8. Hanscom**
- N9. White Pond**

For the purpose of this plan, large agricultural areas in Town are defined as extensive areas of contiguous agricultural or medium-sized farms close to one another that are predominantly open and possess prime farmland soil (i.e., fertile and well-drained) over at least one-third of the area (see Open Space Framework Map). Adjacent wooded parcels on prime farmland soil are included in the map because they represent potential cultivation areas in Town. Large agricultural areas may also include limited areas of wetland or an occasional building. These large agricultural areas were identified based on their opportunity for providing more efficient farm operations and fewer opportunities for negative impacts associated with adjacent development. While valuable to individual farmers and the community, small farmlands or isolated fields

Soils

Large portions of soil in the northern half of Concord are hydric. The high water table corresponds with hydric soils and shallow depth to bedrock in all places except for Punkatasset Hill. Hydric soils and high water table create ideal conditions for the abundant water resources in Concord such as the Great Meadows National Wildlife Refuge.

Prime farmland has the best combination of physical and chemical properties for producing food. The soils are of the highest quality and can economically produce sustained high yields of crops when treated and managed according to acceptable farming methods.



Great Meadows Wildlife Refuge

Source: By Liz West (Flickr: Great Meadow edit) [CC-BY-2.0 (<http://creativecommons.org/licenses/by/2.0>)], via Wikimedia Commons



Pied-billed Grebe by Ryan Schain

CARLISLE

BEDFORD

ACTON

LINCOLN

MAYNARD

SUDBURY

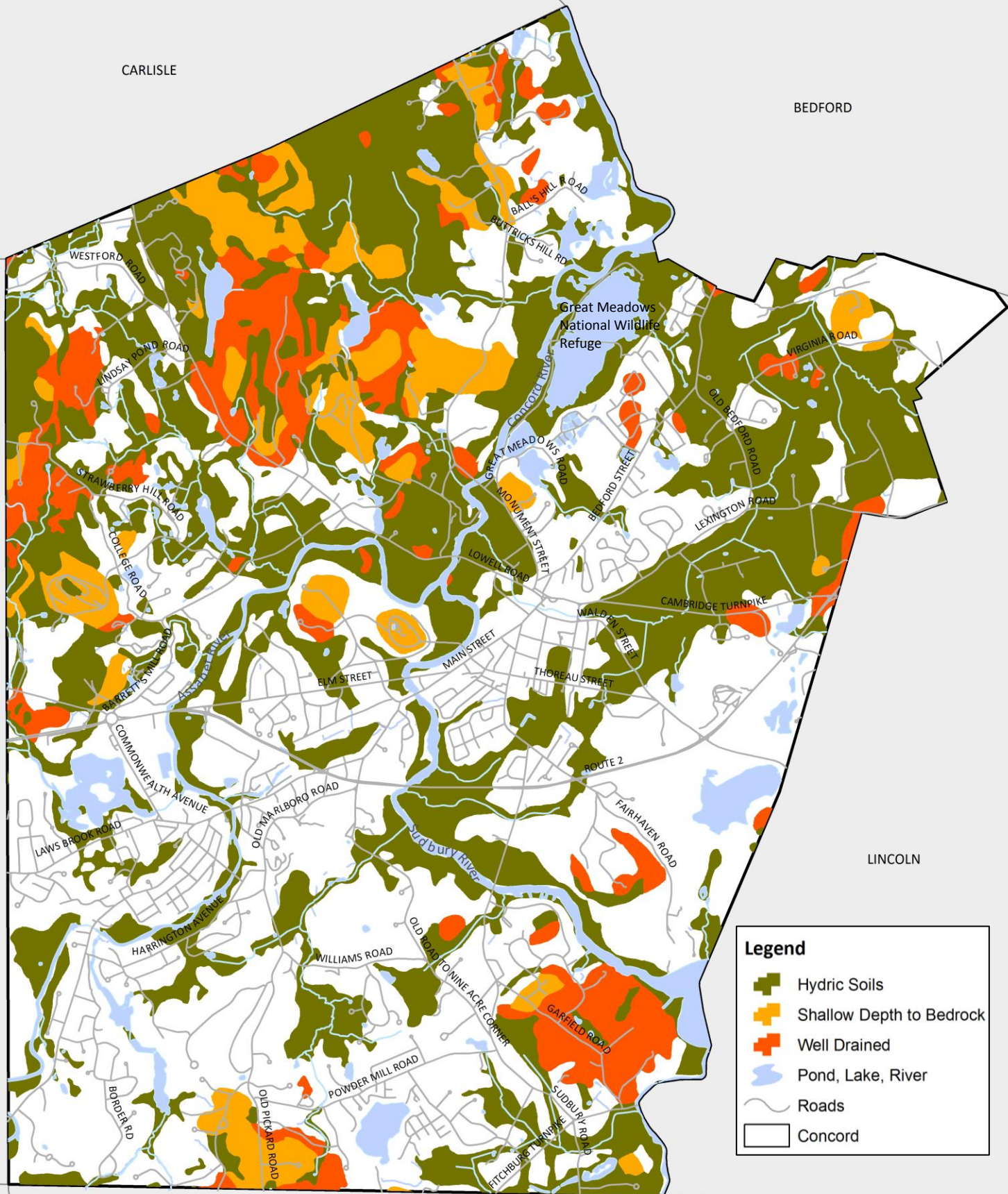
WAYLAND

Soils

Legend

- Hydic Soils
- Shallow Depth to Bedrock
- Well Drained
- Pond, Lake, River
- Roads
- Concord

0 0.25 0.5 1 1.5 Miles



in Town were not included in the large agricultural areas category and would need to be evaluated for protection on a parcel-by-parcel basis. In the 2004 OSRP, five large agricultural areas were defined:

Large Agricultural Areas:

- A1. Nine Acre Corner
- A2. Lexington Road
- A3. Monument Street
- A4. Williams Road / Sudbury Road / Route 2
- A5. Reformatory Farms / Barrett's Mill Road



Buckwheat at McGrath Farm, by Delia Kaye

Agricultural areas near roads, railroads, paths, and scenic points contribute significantly to the residents' perception of the open and rural character of the Town.

The areas provide farm products such as row crops, fruits, vegetables, eggs, and meat. The historic symbolism of farmland in Town, the availability and convenience of fresh produce for residents and the metropolitan market, and the ethics of protecting prime food-producing areas in a world with growing climate instability and increasing fossil fuel costs, all represent reasons why farmland is an important resource in Concord. Furthermore, active farmland is valuable in meeting other community priorities including recreation (such as perimeter trails around farm fields), education (school groups and youth programs that connect students with nature, science and food), historic preservation (keeping alive the agrarian landscape and values upon which the community and country were built), and as a way of serving others (growing food to contribute to local food production and to benefit needy communities). Finally, some agricultural areas enhance game populations and increase the Town's wildlife richness by providing habitat for species requiring large open areas.

Agricultural Soils

Prime agricultural soils in areas to the northwest and southeast of Concord Center have provided fertile ground for farmers for centuries. Its long agricultural history defines much of Concord's character. Many of the prime agricultural soils have already been built on (see buildings in grey on the map). However, there are still areas of prime agricultural soil that remain undeveloped and should be protected. Statewide Important Farmland is land other than prime farmland that is also highly productive.

C) Water Resources

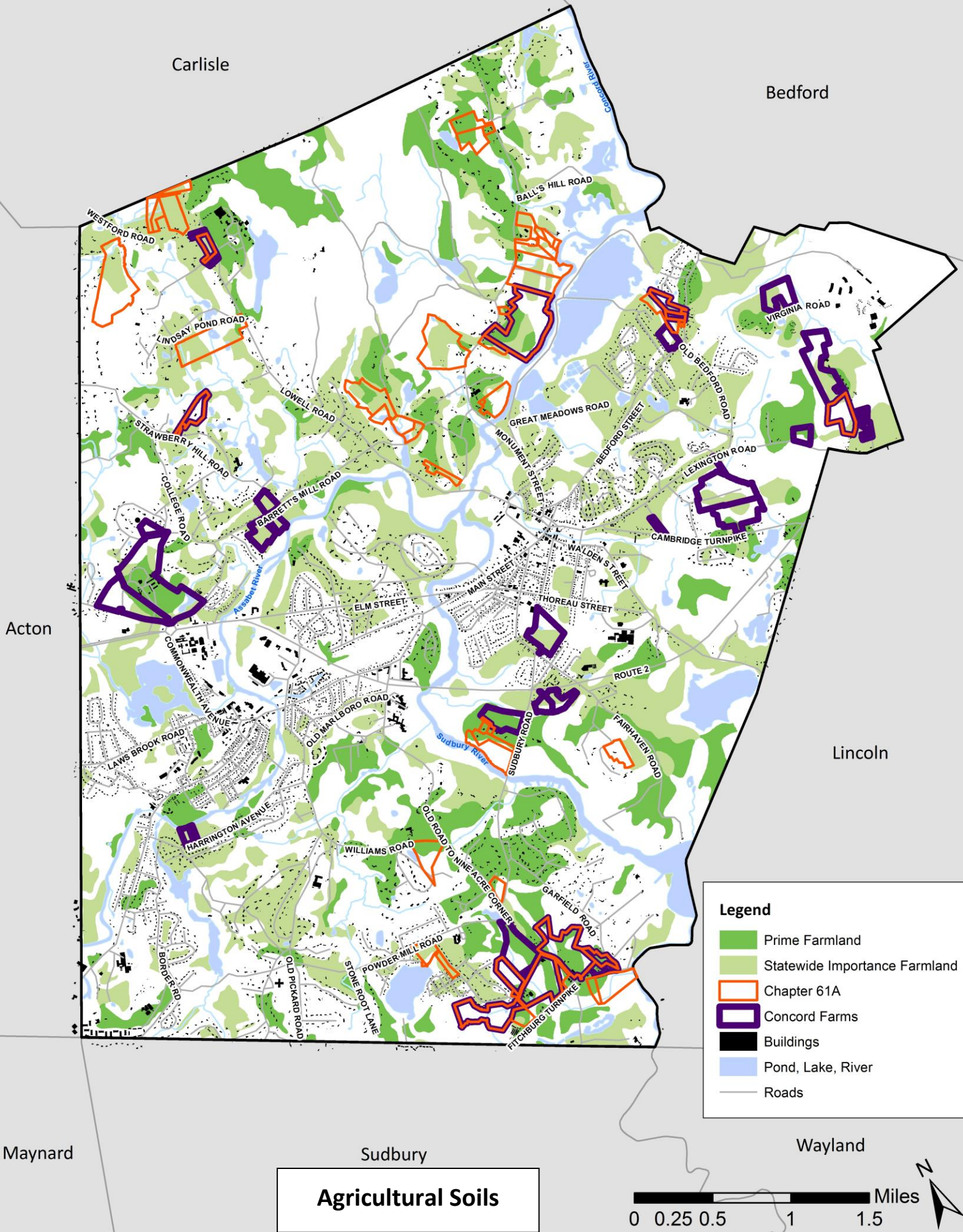
There are five types of water features of particular importance: (1) watersheds; (2) surface water; (3) aquifer recharge areas; (4) flood hazard areas; and, (5) wetlands.

C.1. Watersheds

Concord sits within the SuAsCo watershed, consisting of the Sudbury, Assabet, and Concord sub-watersheds. The Sudbury River originates in the Great Cedar Swamp in the town of Westborough and flows north through the Sudbury Unit of the Great Meadows Wildlife Refuge before entering Concord at the southern border. The Assabet River, also originating in Westborough, enters Town at the southwest corner. Both rivers continue a northward trajectory, joining to form the Concord River in the center of Town at the confluence point known as Egg Rock. The Concord River then continues north for approximately 16 miles before emptying into the Merrimack River in Lowell. The entire watershed drains roughly 377 square miles of land, affecting 36 municipalities and roughly 365,000 people.⁶³

Stormwater discharge and other aspects of development in Concord affect the quantity and quality of water in streams, ponds, wetlands and the ground. Open space in Concord is a major controller of both water quality and quantity, which in turn are important determinants of habitat quality, biodiversity, natural processes, and recreation. The central location of the Town within the watershed has implications both for water quality beyond town borders and for those waters flowing in from the sources discussed above.

The Source Water Assessment Program (SWAP), established under the federal Safe Drinking Water Act, requires every state to inventory land uses within the recharge areas of all public water supplies; assess the susceptibility of drinking water sources to contamina-



tion from these land uses; and publicize the results to provide support for improved protection. The top five potential threats to public water sources in the state that were identified through SWAP are:

- 1) Residential lawn care/gardening;
- 2) Residential septic systems and cesspools;
- 3) Residential fuel oil storage;
- 4) Stormwater discharge; and
- 5) State-regulated underground storage tanks.

The Massachusetts Department of Environmental Protection has fulfilled this federal requirement, and a detailed report is maintained for public at the Concord Public Works Water & Sewer Division.

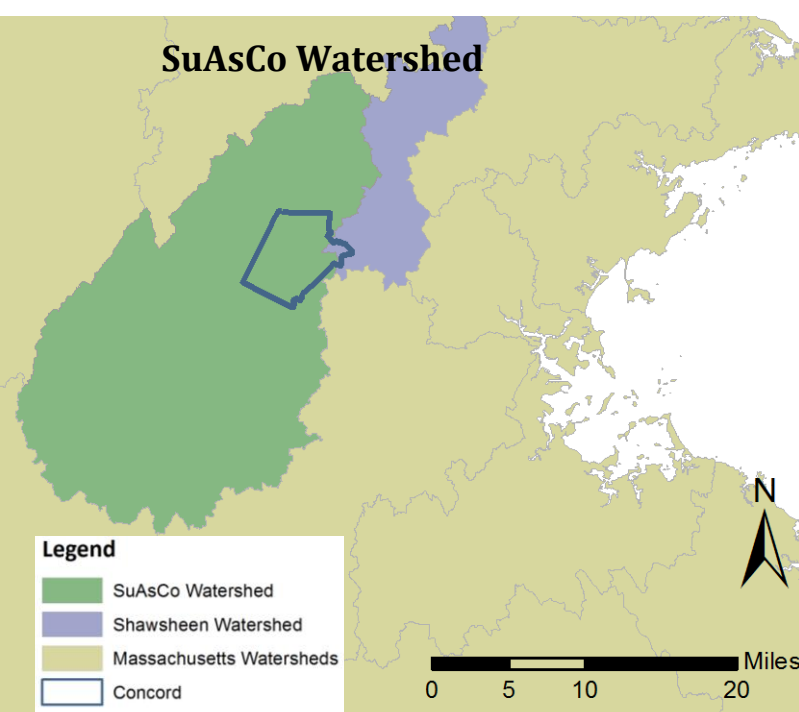
C.2 Surface Water

Primary recreational uses of water resources include canoeing, boating, and fishing in rivers, and fishing in streams and ponds. Swimming is popular in Walden, White, Silver Hill, Kennedy's, and Annursnac Ponds, and canoeing or boating in Walden, White, Warner's, and Bateman's Ponds. Fishing and ice skating occur at most ponds. Essentially all areas adjoining surface water bodies provide recreational value for walking and enjoying nature, although not all of these areas have public access. There is public access in navigable rivers and streams, and in and around Walden Pond. Fishing and boating access, along with passive recreation access, is publicly accessible at White and Warner's Pond, and smaller ponds such as Macone's,

Hutchins, and Fairyland. In order to maintain recreational opportunities and preserve water quality it is important to protect the land adjacent to surface water. Protecting and enhancing certain water bodies is a focus of OARS (Organization for the Assabet, Sudbury and Concord River), the Mill Brook Task Force, White Pond Advisory Committee, White Pond Association, and Silver Hill (Pond) Association.

Ponds are a critical part of Concord's open space and recreational resources on a regional, town, and neighborhood level.¹ On a regional level, Walden Pond, an "outstanding resource water," is a key shared resource for Concord and Lincoln.^{49, 60} Both towns have to cooperate with the State in protecting and managing this high-value resource which draws visitors from around the world. Warner's Pond is impacted by stormwater runoff from Acton, Boxborough, Carlisle, Littleton, Stow, and Westford. White Pond is subject to activities in Sudbury. The impoundments in the Great Meadows National Wildlife Refuge, recreational ponds at the Musketaquid and Concord Rod and Gun Clubs, and Macone's skating pond off Lowell Road are examples of ponds that provide both wildlife habitat and outdoor recreation. On a neighborhood level, smaller ponds, such as those belonging to local associations, serve as centers for community activities. Some larger ponds, such as Kennedy's Pond, are also at the center of neighborhoods. Fairyland Pond is a neighborhood pond for the Concord-Carlisle High School, as is Bateman's Pond for Middlesex School.

While Walden and Fairyland ponds are already protected as open space, others, such as Kennedy's and Warner's Pond, could have more protection of their surrounding land. In addition to outright purchase of such land (the Natural Resources Commission currently owns 118.6 acres around Kennedy's Pond and 34.5 acres adjacent to Warner's Pond) the Town should consider other tools, including conservation restrictions and shoreline zoning. Particularly where ponds can provide neighborhood outdoor recreation, private fundraising and Community Preservation Act funds for acquisition is possible, perhaps in conjunction with a land trust. Municipal land by ponds may contain some undeveloped land that should be managed for conservation values until needed for town services, thus maintaining both conservation value and long-term land-use flexibility. In the case of municipal land near White Pond, parts of the property should be permanently conserved to better protect the pond; however, Town needs will first need to be evaluated. In order to raise awareness about surface water resources among residents, an educational wetlands bro-



chure, *A Homeowners Guide to Working Near Wetlands and Streams*, was mailed to all residents and provided to real estate agents and others in 2012. It highlights the key regulatory provisions and the importance and values of buffers adjacent to wetlands. Additionally, a watershed management plan was developed for Warner's Pond in 2012 and one is presently being developed for White Pond.

Surface Water Classifications are designations applied to surface water bodies, such as streams, rivers and lakes, which define the best uses to be protected within these waters (for example swimming, fishing, drinking water supply) and carry with them an associated set of water quality standards to protect those uses. Currently, the water classification of the three major rivers is B: Sudbury River (warm water fishery/treated drinking water supply), Assabet River (warm water fisheries), and Concord River (warm water fishery, treated water supply).^{42, 55} Class B waters are designated as habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. The Organization for the Assabet River has been testing the water quality of the Assabet since 1992, and currently conducts water quality, streamflow, and biomass monitoring on the main stems and large tributaries of the Assabet, Sudbury, and Concord Rivers.⁵⁵ The Mill Brook Task Force, Warner's Pond Stewardship Committee (2004-2012), and the White Pond Advisory Committee are the only town-sponsored groups focused on stewardship of a Concord surface water body. Other, similar groups or perhaps a broader stream/river group or surface water group might be formed to coordinate numerous stewardship opportunities across the Town. Such a group or groups could be effective in educating residents, in conducting a water-quality survey, and in other important roles.

The South Bridge Boathouse provides access to Concord's rivers, which are a major regional canoeing or kayaking attraction. The only other widely used recreational access to the rivers is next to the Lowell Road bridge. In 2005, the Lowell Road boat launch was upgraded to provide a more formal and stable access point to the river, facilitating canoeing and fishing. Since 2004, the Assabet River has been made accessible from the parking lot of Dino's Pizza (behind 1135 Main Street), and also from the Westvale boat launch located off Main Street just before the Westvale Meadows Condos. Boat launches also exist at the Pine Street Bridge, Warner's Pond, and White Pond. Canoe access for the Sudbury River and Fairhaven Bay is

A palette of well-known techniques for homeowners that can greatly reduce stormwater system runoff:

- Drains from roofs and driveways can be directed to surface depressions, vegetated swales, underground cisterns, aboveground rain barrels, water gardens, and more, in all cases to prevent roof-water runoff from reaching road drains.
- Cisterns and rain barrels can be used for watering gardens and even for certain indoor uses.
- Homes with groundwater wells should be expected and required to conserve water just as everyone else does (no lush green lawns during droughts), since pumping groundwater out during dry periods can quickly degrade nearby streams, ponds, and vernal pools.
- Strategic planting of native shrubs and trees on grassy or bare slopes reduces surface runoff.
- Homeowners can replace hard surfaces such as patios, driveways, sidewalks and parking lots with porous materials and surfaces.

also available in Lincoln on Route 117.

The Concord Department of Public Works (CPW) has taken significant measures to minimize the amount of pollution and sediment that drains from impervious surfaces into the stormwater system. CPW complies with Concord's infiltration/inflow control plan (initiated in September 2006) and submits annual reports in accordance with EPA National Pollutant Discharge Elimination System (NPDES) permit issued to the Town's Wastewater Treatment Plant. Measures that the CPW has taken include: the design and implementation of Low Impact Development (LID) techniques to minimize the amount of impervious material; construction improvements and upgrades to existing stormwater infrastructure, such as deep sump basins and infiltrating catch-basins; the institution of house-keeping programs to minimize sediment accumulation, including annual catch-basin cleaning and street sweeping; and, establishing household hazardous waste and unwanted pharmaceutical/personal care product collection events. The Town also has a Twenty Year Stormwater/Drainage Management Plan to address the backlog of deferred repairs and the need to replace large culverts in Town.⁵⁸

As the amount of impermeable surfaces increase, typically groundwater recharge is reduced, the water table drops, pond levels go down, wetlands shrink, streams become smaller, and vernal pools dry out sooner, all tending to cause significant ecological loss for Concord.

C.3 Aquifer Recharge Areas

The Nagog Pond surface water supply is located approximately five miles north of Concord in the towns of Acton and Littleton. Nagog Pond is a great pond with the majority of recharge from surface runoff and ground water recharge (thought to be through fractures); it has very limited tributary flow during times of high precipitation. Nagog Pond has a surface area of 0.44 square miles with a corresponding watershed area of only 1.25 square miles. The watershed comprises low density residential, conservation/protected land, and a small amount of commercial land in Nagog Park. Concord has a state-approved Nagog Watershed Resource Management Protection Plan, which includes comprehensive water quality monitoring, watershed surveillance, and watershed public outreach programs. Activities such as swimming, boating, and horseback riding along the shore are prohibited. In the early 1990s, curbing was installed along with a stormwater collection system that diverts stormwater out of the Nagog Pond watershed northeast into the Nashoba Brook watershed.

Access to both surface water and groundwater watershed lands has been restricted by posting “Public Water Supply Land – No Trespassing” signs. In select cases, where the Water and Sewer Division works closely with adjoining landowners, passive recreation, such as hiking on marked trails, is accepted. There is no active recreation, agriculture, or farming authorized on watershed lands, except when approved by the Water and Sewer Division, on a case-by-case basis.

C.4 Flood Hazard Areas

In addition to the Assabet, Sudbury, and Concord Rivers, Concord has many major streams or brooks (see Water Resources Map): Elm; Mill; Jennie Dugan; Nashoba, Spencer; Second Division; and Saw Mill, in addition to smaller brooks. A considerable area of Concord is subject to the statistical 1% annual chance flood event (100-year floodplain), though rather little additional area is subject to the calculated 500-year flooding (see Flood Zone Map).

Flooding occurs routinely in Concord and ranges from minor inconveniences to major damage (property damage, blockages of roadways or bridges vital for emergency response, and breaching of dams). The Town uses several mitigation strategies to alleviate flooding including the Massachusetts Stormwater Management Policy, beaver management, Twenty-Year Stormwater/Drainage Management Plan, and regular maintenance of culverts, drainage pipes, and

Water Resources

With the confluence of three rivers in the center of Town, Concord is especially well-endowed with wetland resources. Beaver activity generally extends the area of wetlands and increases habitat types and biodiversity. A state law passed in the mid-1990s eliminated most forms of beaver trapping, so, as elsewhere in the state, the town’s beaver population has grown noticeably.

other infrastructure. Concord’s drainage infrastructure consists of 124 culverts, 183 drainage outfalls, 2,522 catch basins, 751 manholes, and 50 miles of drain lines.⁵⁸

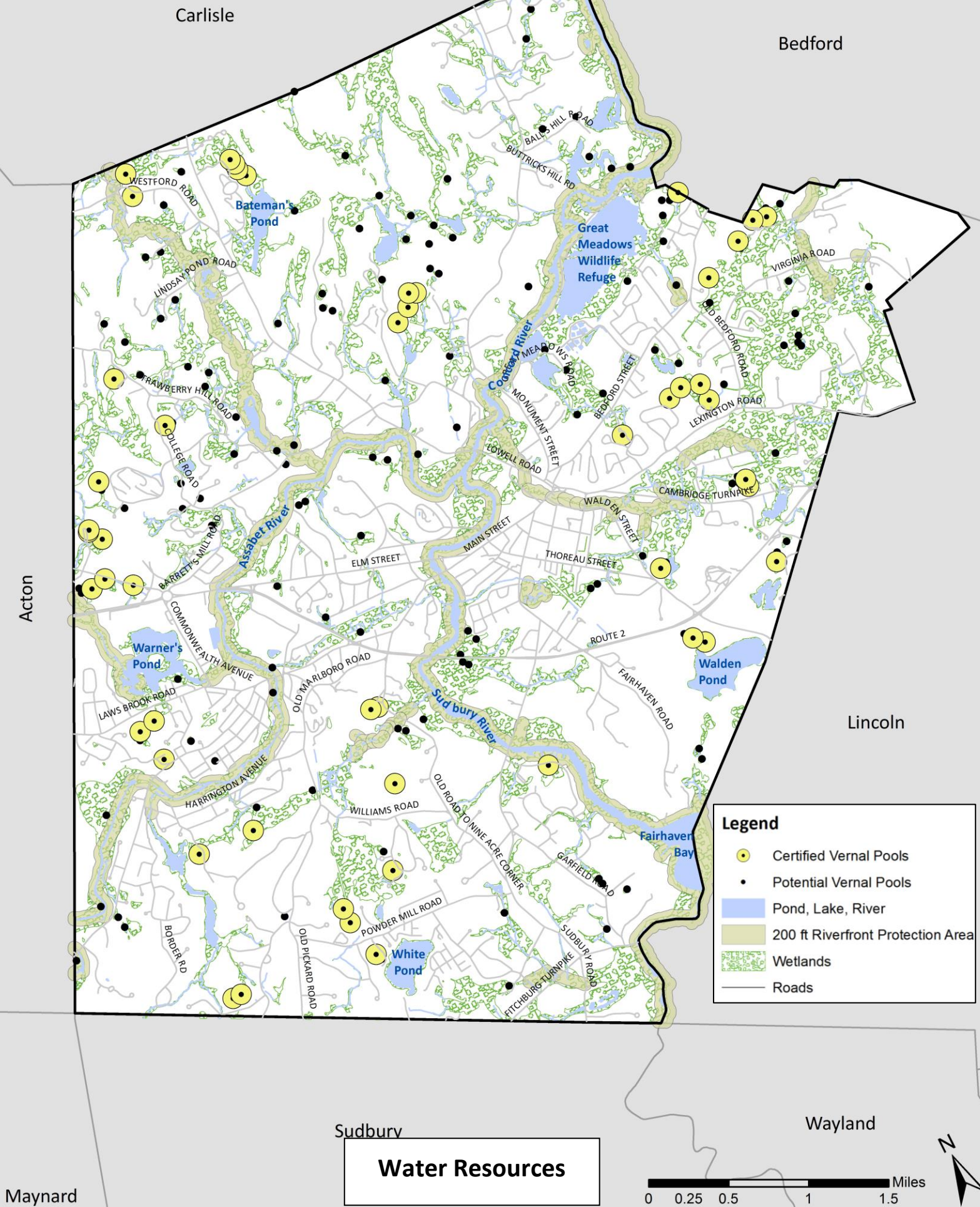
In the early 1990s stretches of the Sudbury, Assabet, and Concord Rivers were, with state and local collaboration, designated as Wild and Scenic Rivers. This provides some limits on alterations in and development near these rivers that are “outstanding resource waters.” In 1997, the state passed a Rivers Protection Act that protects a 100-foot buffer adjacent to perennial streams against development and permits only certain activities within 200 feet of perennially flowing streams and rivers.

C.5 Wetlands

Wetlands are protected by federal, state, and local laws. Filling and draining wetlands, altering the soil, cutting vegetation, and developing land within 100 feet of wetlands or within 200 feet of a perennial stream are regulated and require approval from the Natural Resources Commission.

In order to better protect its wetlands and water resources, Concord passed a Wetlands Bylaw in 2009. To help provide both long-term and improved protection of these valuable resources, the Wetlands Bylaw codified a 25-foot No Disturb Zone policy that the Commission has implemented since 1994, provided 100-foot protection to Certified Vernal Pools, and instituted an ability to impose fines. The Wetlands Bylaw, in conjunction with the River’s Protection Act, results in the preservation of valuable corridors in the Town that link some of the larger natural areas. The Commission also continues to enforce a 50-foot No Build Zone policy, first implemented in 2004, to better protect wetland resource areas.

Water protection corridors include the water resource itself, as well as the associated strips of natural vegetation around ponds and along both sides of rivers and



streams. Trees and shrubs normally dominate these corridors in this region. These corridors provide several resources: clean water for drinking, swimming, and fishing; fallen logs and branches for critical fish habitat; shade to maintain cool water temperatures in summer; and leaf litter as a base of aquatic food webs. Water protection corridors help absorb stormwater and chemical runoff (fertilizers, pesticides, septic seepage, chlorine from pools, and other inorganic and toxic substances). The corridors also help reduce soil erosion, the scope and frequency of flooding, sedimentation, and loss of bottom fish habitat. They also serve as wildlife corridors.

D) Vegetation

It is likely that Concord is the most intensely botanized town in the United States for the longest period of time, starting with the brothers, Edward and Charles Jarvis in the 1820's and 1830's and continuing to the present day. Concord is endowed not only with a rich literary and historical heritage, but also with a wealth of habitats – three rivers, many ponds, brooks, meadows, bogs, swamps, marshes, deciduous-coniferous woodlands, open sandplains, fields, hills, ledges, and acidic as well as some circumneutral soils. It is situated close enough to the Atlantic coast to pick up elements of the coastal plain flora coming up from the south and far enough north and inland to pick up some elements of the boreal forest flora extending southward from northern New England.⁶⁵

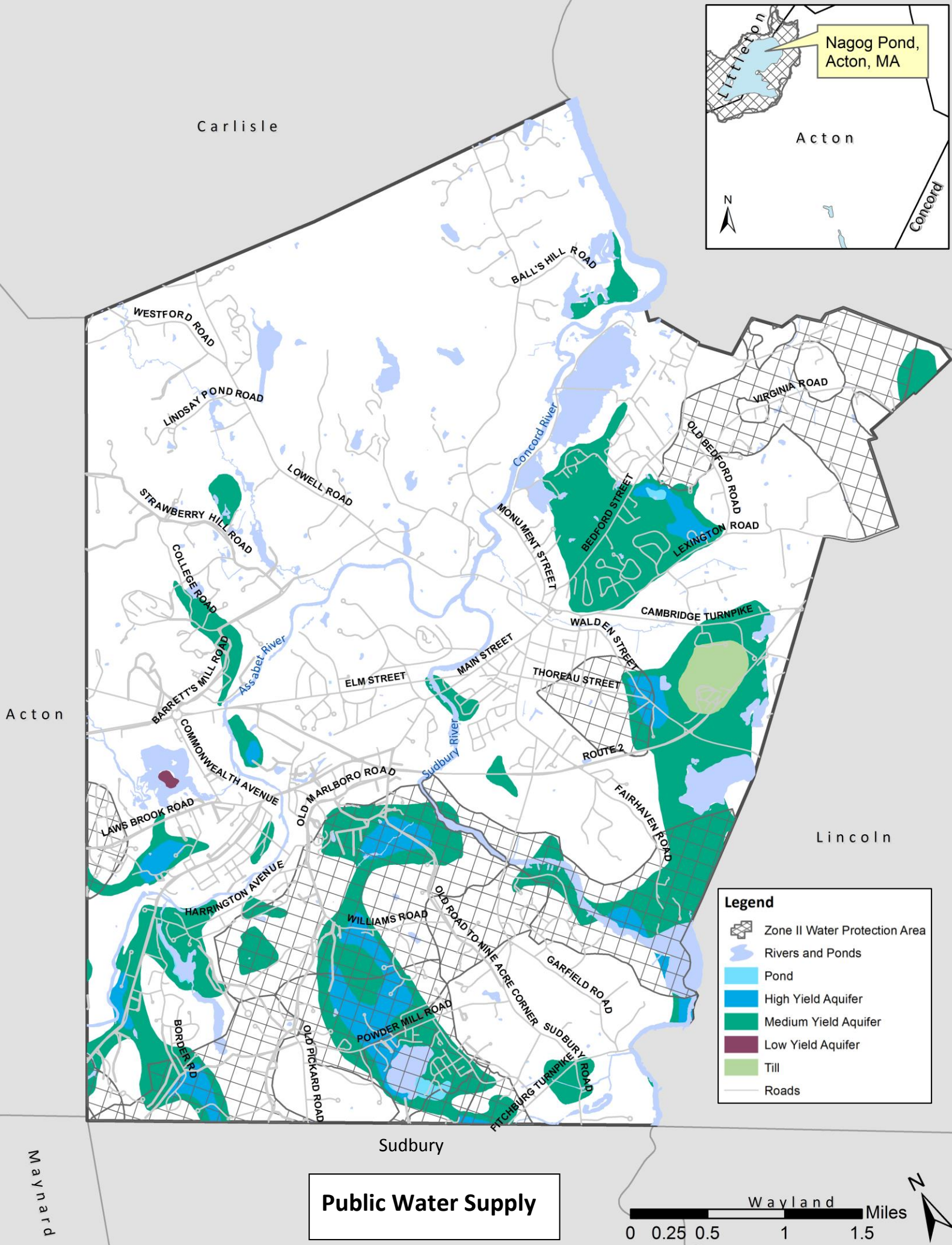
Concord's botanical legacy has been most solidly founded on the detailed observations and records of Henry David Thoreau (1817-62) and those he inspired to continue to study Concord's evolving flora thereafter. Following his death, Sophia Thoreau (1819-71), Edward S. Hoar (1823-93), Minot Pratt (1805-78), Alfred W. Hosmer (1851-1903), Herbert W. Gleason (1855-1937), and Richard J. Eaton (1890-1976) all made significant contributions to the Town's botanical record. From the late 1970's to early 1980's, amateur botanist and former curator of the New England Botanical Club, Ray Angelo spent nearly three decades comparing Thoreau's herbaria records and Journal entries to the Town's historical botanical record and his own exhaustive field explorations and inventories, in order to compile all of these observations into an annotated inventory with updated locations and place names.⁶⁵ This past decade has brought a resurgence of fieldwork, scholarship, and public interest focusing on Concord's flora. Dr. Richard Primack (Boston Uni-

Public Water Supply

Protection of land around groundwater wells is important for maintaining both the quantity and quality of groundwater. Designated aquifer-recharge areas for the wells are protected under the state's Department of Environmental Protection Zone I and Zone II regulations and Town Groundwater Conservancy Districts. These zones encompass a large amount of land in which certain activities are regulated to minimize pollution. Concord Zone II protection areas include land managed within other towns. Conversely, there are Zone II protection zones from the towns of Bedford and Acton that encompass Concord land.

versity) and Dr. Charles Davis (Harvard University) made use of Concord's botanical record, particularly the phenological data compiled by Thoreau, to study climate change and its possible impacts on the northeastern United States. Dr. Bryan A. Connolly, Massachusetts state botanist, has been conducting ongoing field visits to verify some of Concord's rarer plant species. In 2013, the Concord Museum presented an exhibition, "Early Spring: Thoreau and Climate Change," providing an overview of Concord's botanical legacy, changes in its flora, and possible impacts that might be attributed to climate change.

While Concord's predominant plant communities are characteristic of southern New England, the Town has a higher than average diversity of natural communities and flora due to the presence of three rivers, an abundance of wetlands, its glacial profile, and its situation both at the western edge of the coastal plain and the southern extent of boreal plant communities.^{1, 20, 29} Its upland forest matrix of transition hardwoods grow on well-drained, acidic glacial till and typically include red oak, white oak, black oak, white pine, black birch, and hickory species. Depending on orientation, slope, and drainage, these mixed hardwood stands may also include hop-hornbeam, American beech, American chestnut stump sprouts, hemlock, white birch, sassafras, and hazelnut species. A locally rare sugar maple-oak-hickory stand growing within a larger oak-hickory matrix in Conantum was first reported in Thoreau's Journal (September 17 and 24, 1851). It was subsequently relocated by Angelo in 1983, and reconfirmed and photographed by Cherrie Corey in October 2013 in a steep ravine along the southern boundary of Concord Land Conservation Trust's Anderson Woods



parcel, partially within an abutting private parcel. A few pockets of northern hardwood-hemlock-white pine grow along glaciated, north-facing slopes, including the northwestern end of Brister's Hill in the Town Forest. Pitch pine, which was once prevalent in the forested landscape into the mid-nineteenth century, now appears as a forest remnant or in reclamation areas, such as the one atop Brister's Hill, where the species was once naturally abundant. A few healthy, old growth pines and hemlocks of significant age and size still stand in protected areas of the Town Forest, Estabrook Woods, the Old Rifle Range, and along Conantum's western ridge.

Concord's landscape, within the floodplain of three rivers and set upon the gravel and sand till of glacial lake bottom soil, made it an especially attractive inland location for indigenous farmers from 1000-350 years ago and for its colonial founders in 1635, who sought a suitable landscape in which to resettle, farm, and feed their livestock away from the fractious religious and political climate in Cambridge and Boston. Beginning in the mid-1600's, the Town's early European settlers followed their cultural roots in designating an agricultural commons, the Great Field, which ran from the town center out through its East Quarter. The Town's Meriam-Burke, McHugh, and Kenney Farm fields are evidence of this long history, still in cultivation today and providing historic vistas. The Great Meadow provided abundant wet meadow hay for livestock from the mid-17th to late-18th centuries until deforestation and large river dams raised water levels and decimated the meadow grasses. Ultimately, it was impounded by landowner Samuel Hoar and, later, the U.S. Fish and Wildlife Service to create marshland for wildlife conservation in the early to mid-20th century.

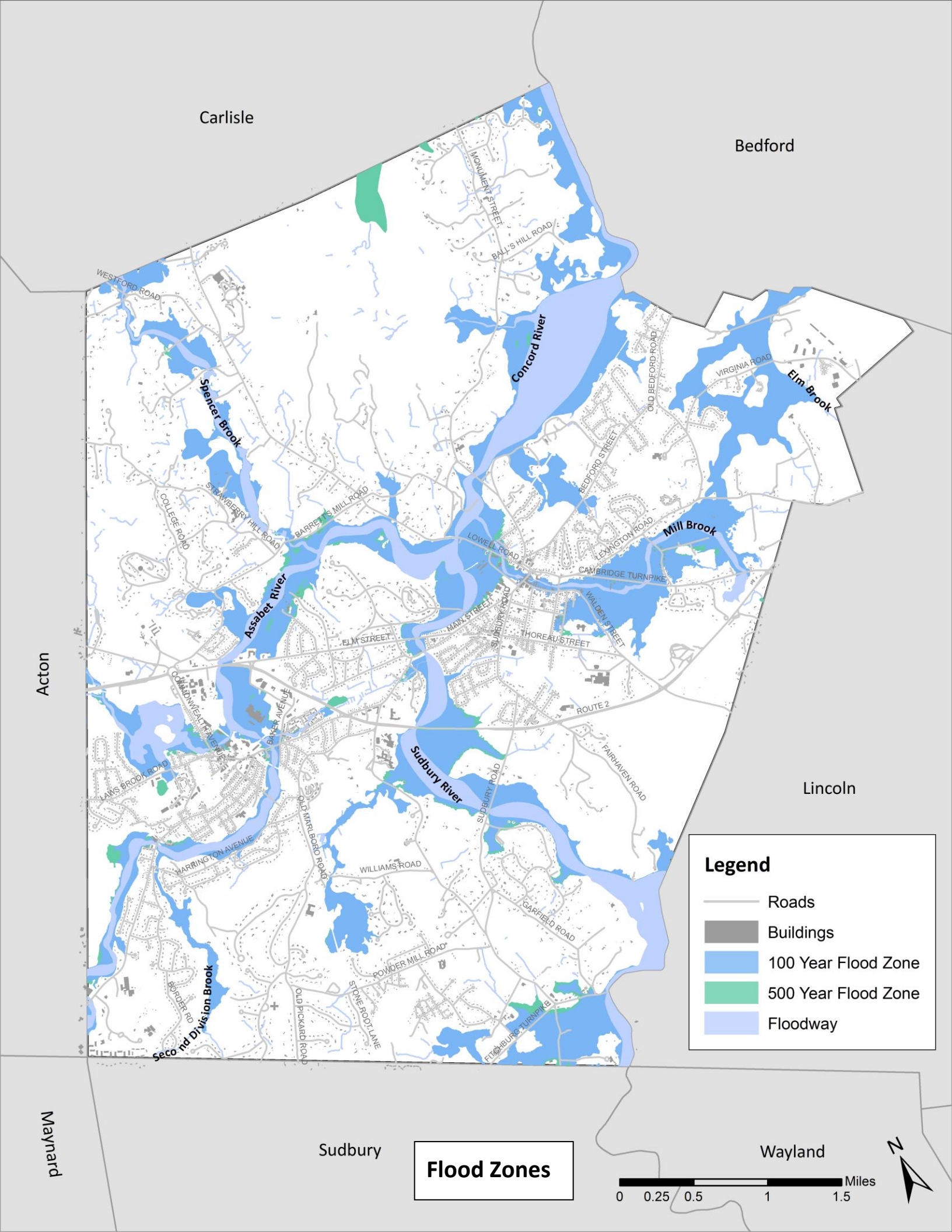
Today, Concord is distinguished by a diversity of wetland communities and plant associations, several of which are classified by the Natural Heritage and Endangered Species Program(NHESP) as priority natural communities that are imperiled or vulnerable, including stretches of small river floodplain forest along its three rivers, alluvial red maple swamp (at Great Meadows), level and kettlehole level bogs (most notably Gowing's Swamp, Bose's Meadow, and Jenny Dugan Kames bog), and acidic fens (the Andromeda Ponds and Heywood Meadow, west and southwest of Walden Pond). In addition, Concord has extensive shallow and deep emergent marshlands, numerous shrub and red maple swamps, wet meadows, highbush blueberry thickets, and inland acidic pond shore habi-

tat.

One of these wetland areas, Gowing's Swamp, stands out as perhaps the longest studied and most written about bogs in North America. In 2010, local naturalist Cherrie Corey completed a botanical inventory and historical survey of the Gowing's Swamp basin and the surrounding 13 acres of conserved upland forest and abutting vernal pools and cultural grassland, publishing a detailed historical and botanical report for the Sudbury Valley Trustees, titled *Gowing's Swamp and Thoreau's Bog, An Historical Wetland in Concord, MA*.²⁵ Based upon this updated research and hydrological data provided through MIT Professor Harold Hemond's 30-year study of the wetlands hydrogeology, the entire 8.9-acre wetland basin was determined to be fully a kettlehole level bog, perched above the divide of two watersheds, and not a boggy depression within a red maple swamp as previously characterized by Richard Eaton in 1969. Of the 220 plant species recorded, several are locally rare or significant including two separate stands of black spruce (one with 400+ trees, the only remaining significant stand in Concord), tamarack, bog rosemary, pale laurel, small-flowered cranberry, and numerous purple pitcher-plants. Some 52 species of lichens were recorded within the bog basin, a number of which are locally rare and highly sensitive to habitat disturbance and air pollution.²⁵ Gowing's Swamp is the most floristically diverse and intact bog remaining of some dozen bogs described in Concord's historical record. Care should be taken to minimize future impact on the bog by any alteration of the surrounding water table or its water chemistry, by localized exposure to sulfur dioxide emissions, by rapidly encroaching invasive plant species along its shoreline, and by the impacts of increased use of shoreline trails and egress onto the bog mat by the public and visiting dogs.

Flood Zones

A considerable area of Concord is subject to the 1% annual chance flooding probability (100-year floodplain), though rather little additional area is subject to the calculated 500-year flooding. The amount of stormwater over Concord's impermeable surfaces could cause flooding with potentially damaging effects on basements, septic systems, driveways, and roads and bridges in Town. Major floods with higher peak flows have the potential to transform and rearrange Concord's floodplain habitats and degrade fish populations in its waterways.



Three areas in Town support interesting pockets of locally rare flora due to calcite outcrops and circum-neutral soils, including Estabrook Woods (from Punkatasset Hill to Mink Pond, the lime quarries, and Bateman's Pond), Conantum, and on the east side of Annursnac Hill. While some of the species found in these areas were introduced by nurseryman Minot Pratt in the early to mid-19th century, and have since naturalized, other species appear to be native to these sites. Recreational overuse (principally wandering hikers, dogs, and trail bikes) are now causing the most immediate and obvious impact on these populations, especially in Estabrook Woods and at Martha's Point in Conantum, overlooking Fairhaven Bay.

Over the past 160+ years that Concord's flora has been intensively documented, increasing changes are being noted to both the overall profile of its plant communities and to some of the more unusual and specialized species within these areas. The impacts come from a host of factors which have shifted in significance over time, including: deforestation, reforestation; predation; disease; development (filling, dredging, contaminating, displacing the water table); changing air/water quality; increasing recreational degradation; precipitous spread of invasive introduced species; disappearance of pollinators; and, climate change. Some of these impacts can be mitigated with mindful town planning, land management, and public education while others are more complex, longer term, systemic problems, needing further study and wider resolution.

In addition to the natural vegetative communities, the Town Tree Warden manages 15,000 – 20,000 street trees, mostly along the streetscape, but also within recreational and public spaces. One hundred fifty trees are planted annually from a mix of 30 species (mostly native) to help diversify the native population. An inventory will be conducted in 2015 as a first step towards developing a master plan for the street tree program.

E) Fisheries and Wildlife

Because Concord is situated at the junction of the Asabet and Sudbury/Concord Rivers, and is blessed by large tracts of conservation land, the Town is able to host a wealth of wildlife species, unusual in a town so close to a major metropolitan area. Concord is, and has always been, a mecca for naturalists, with the result that Concord flora and fauna are among the most heavily studied in the nation with detailed records dating back to the journals of Henry David Thoreau.

Plant and Wildlife Habitat

Concord has 50 Certified Vernal Pools and 154 Potential Vernal Pools, and large portions of the Town, especially in the north, provide core habitat for rare and endangered species as shown by BioMap2 on the following page. Potential vernal pools should be evaluated and certified as appropriate.



Muskrat by Cherrie Corey



Britton's violet by Cherrie Corey



Northern Harrier by Ryan Schain



Praying Mantis by Ryan Schain

Acton







Lincoln

Sudbury

Wayland

Plant and Wildlife Habitat

Legend

-  Beaver Dams
-  Certified Vernal Pools
-  Potential Vernal Pools
-  Lake, Pond, River, Impoundment
-  BioMap2 Core Habitat
-  Wetlands
-  Roads

0 0.25 0.5 1 1.5 Miles



Orange Sulphur by Ryan Schain

Over the years, Concord-based organizations and the Town's residents have secured large tracts of open space which serve as habitat for many species of wildlife and which are used for wildlife compatible outdoor recreation. These tracts include the 1,200-acre Estabrook Woods, protected by numerous stakeholders, some 900 acres of conservation land owned by the Concord Land Conservation Trust, 1,360 acres of Town conservation land, and the 2,680-acre Walden Pond Reservation managed by the Commonwealth of Massachusetts' Division of Conservation and Recreation.

Because of the extent and diversity of wildlife habitat, wildlife is abundant and populations are healthy. To document the amazing wealth of wildlife, Concord launched the first Massachusetts biodiversity day in 1998 when, led by Peter Alden and Dr. Edward O. Wilson, Concord residents rose to the challenge of finding 1,000 species. Surpassing the challenge, they found 1,905 species and a few years later the state's Office of Environmental Affairs adopted the challenge state-wide.

Vegetation, wildlife, and biodiversity have changed markedly over four centuries of major human and land-use impact.^{28, 31, 34, 35} A major hurricane hit Boston in 1635, hurricane eyes passed within about ten miles of Concord in 1804 and 1869, and a 1938 hurricane caused extensive tree blowdowns, property damage, and, presumably, biodiversity changes in Town.³⁴ While recent storms have caused flooding in Concord, they have not caused high enough winds to inflict extensive damage.

E.1 Inventory

Mammals: White-tailed deer numbers are high in many parts of Town, as are numbers of many of the state's most adaptable mammals including coyotes, raccoons, and beaver. Where deer populations are high, some residents enjoy viewing them. Other residents bristle at the damage to ornamental plantings and the increase in tick-borne diseases, and concerns over impacts to forest health from excessive deer browse on native flora.

Biologists recommend holding deer population numbers at 8 – 10 per square mile and seek to manage deer numbers through hunting. Deer hunting opportunities in Concord are relatively limited. Much of the best deer habitat is in private ownership and hunting is further limited by the 500-foot setback regulation which effectively eliminates most of the open lands in Concord.

Less common than deer but equally charismatic are bear and the occasional moose that wander through Town. Moose occasionally make an appearance near the Concord or Sudbury River, though year round residence in Concord is very unlikely. There have been reports of moose using the active railroad line in Concord.

The presence of black bears has been noted from vandalized bird feeders, scat, and sightings, but is unlikely that there is a year-round bear population. There have also been a few reliable reports of bobcat sightings in Concord.

Wild canids—coyote, red fox, and gray fox—are well established in Concord and travel extensively in open space, through yards, along roads, and crossing Route 2. Family packs of coyotes have been reported by residents.

Fishers, relatively large, dark-colored members of the weasel family, are widespread in Concord. The abundance of large white pine trees for denning and the large number of squirrels for food may contribute to their success. Other weasel family members present in Concord are river otter, mink, and long-tailed and short-tailed weasels. Otter use all the rivers and most ponds in Concord to a surprising degree.

The eastern cottontail rabbit population fluctuates considerably. Its cousin, the New England cottontail, may be extirpated from the area. Raccoons are frequently seen, as are opossum and striped skunk; all these species have adapted well to the suburban landscape found in Concord.

Beaver are at home in many wetlands and ponds. If their food supply runs out, they will leave and return when it has grown back up. There are several beaver management devices (Jennie Dugan Brook, Punkatasset, and a newly installed device at Fairyland Pond) that have successfully maintained water levels and prevented flooding; these options are worthwhile considerations to harmonize human/wildlife interactions.

There are only a few locations in Concord where individual porcupines have been seen. Slow moving and undaunted, they are especially vulnerable to vehicles. Hemlocks are an important food source. Given the effects of woolly adelgid on hemlocks, it is possible that the small population of porcupine will further diminish.

Among the small mammals present in Concord are at least four species of squirrel: gray, red, southern flying squirrel, and eastern chipmunk. White-footed mice

are ubiquitous, as are meadow voles. Less common are northern redback voles, pine voles, and meadow jumping mice. Hairy-tailed mole tunnels are frequently seen in sandy areas and the star-nosed mole inhabits many Concord wetlands. Short-tailed shrews and our tiniest mammal, the masked shrew, are also abundant. Muskrat are common in the rivers as well as in large and small marshes.

Sadly, bats have become much rarer in Concord in recent years, as elsewhere in Massachusetts. The primary cause for this decline is the new and devastating infectious disease, white-nose syndrome, which has obliterated more than 95% of our wintering bats since 2008. Big brown bats are likely the species most frequently seen in Concord.

Birds: The birdlife of Concord and the Sudbury Val-

such as eBird (<http://www.ebird.org>) to record their sightings. These types of tools, which now provide nearly instantaneous access to site-specific bird records, are revolutionizing the means by which such data are collected, archived, and disseminated. In 2013, a compilation of eBird records representing the sightings of dozens of local birders, yielded a total of 225 species in Concord (<http://tinyurl.com/p88hqj5>).

The avian richness of Concord is largely attributable to the Town's long-standing history of active land conservation and management, and to the extensive areas of open space that represent the fruits of those efforts. Areas that are notably rich in birdlife include Estabrook Woods, the Concord impoundments of the Great Meadows National Wildlife Refuge, the Dugan Kames Natural Area; the Elm Brook wetlands; Hanscom Airfield, and the agricultural fields at Kaveski

It is in vain to dream of a wildness distant from ourselves. There is none such. It is the bog in our brain and bowels, the primitive vigor of Nature in us, that inspires that dream. Consider how remote and novel that [Gowing's] swamp. Beneath it is a quaking bed of sphagnum, and in it grow Andromeda polifolia, Kalmia glauca, Menyanthes, Gaylussacia dumosa, Vaccinium oxycoccus, plants which scarcely a citizen of Concord ever sees. It would be as novel to them to stand there as in a conservatory, or in Greenland...

Henry David Thoreau - August 30, 1856

ley has been studied and chronicled nearly continuously for more than 150 years. This remarkable ornithological record is unsurpassed in North America. Thoreau laid the groundwork in the mid-19th century, William Brewster continued the tradition from late in the 19th century into the early 20th century, and between the 1940s and 1980s, Ludlow Griscom and Allen Morgan, led the move into the modern era of "birding." Today Concord is still home to professional naturalists and ornithologists and many avid birders. Not coincidentally, the documentation of the town's birdlife has become more thorough than ever.

Bird data collected recently in Concord, using standardized protocols, include the local records from the state-wide Massachusetts Breeding Bird Atlas (2007-2011, <http://www.massaudubon.org/bba2>); the Concord Christmas Bird Count (annually since 1960, <http://netapp.audubon.org/cbcobservation>); town-wide "Biodiversity" events in 1998 and 2008 (<http://www.waldenbiodiversity.com/species-list-2009-1998>); and regular, ongoing surveys at the Concord Unit of the Great Meadows National Wildlife Refuge (unpublished) and Minuteman National Park (unpublished). Additionally, local and visiting birders increasingly use internet-based "citizen science" tools

Farm, Nine Acre Corner, and Barrett's Mill. Estabrook Woods, the Refuge impoundments, and Hanscom, being especially important in terms of their contributions to Concord's avian diversity, are discussed in more detail below.

Estabrook Woods is, by far, Concord's largest tract of unfragmented, mature forest. By virtue of its sheer size and because it contains a wide variety of forest types and microhabitats, including several bogs, its avifauna is probably more diverse than all the Town's other woodland tracts combined. An impressive list of nesting species include barred owl, ruby-throated hummingbird, pileated woodpecker, winter wren, at least eight species of wood warblers including black-throated green warbler and northern waterthrush, along with scarlet tanager, wood thrush, hermit thrush, and veery.

The wetlands that comprise the Concord Unit of the Great Meadows National Wildlife Refuge attract an enormous variety of birds, especially in the breeding season and during the spring and fall migration periods. During migration, refuge staff actively manage the water levels within the impoundments to create conditions that are favorable for migrant waterfowl,



Pectoral Sandpiper by Ryan Schain

shorebirds, and other wetland taxa.

State-listed species that are known to nest in the Concord impoundments include least bittern and pied-billed grebe. Other listed species that occur there, but for which breeding has not yet been confirmed, include American bittern, king rail, and common gallinule. Wood ducks and hooded mergansers nest in the artificial nest boxes and in natural tree cavities along the periphery, and other noteworthy species that nest in the impoundments include Virginia rail, sora, wilow flycatcher, marsh wren, and swamp sparrow. Over 30 species of waterfowl have been recorded at the Concord impoundments. Diving ducks such as ring-necked duck, common goldeneye, and hooded mergansers are more common when the water levels are highest in spring, whereas the numbers of dabbling species such as green- and blue-winged teal, American black duck, and northern pintail peak in the fall. A remarkable total of 30 species of shorebirds recorded at the impoundments has included 5 species of plovers and 25 species of sandpipers, the great majority of which have occurred as southbound migrants in mid-to late summer. At this season, shorebirds feed in shallow pools that form, or on mud flats that become exposed, when water levels are low. Species most commonly recorded include killdeer, greater and lesser yellowlegs, and semipalmated, least, and pectoral sandpipers. The abundance of birds at the impoundments invariably attracts avian predators. Raptors most frequently seen exploiting this food source include bald eagle, northern harrier, Cooper's hawk, merlin, and peregrine falcon.

Despite its conspicuous differences with the rest of Concord's open spaces, Hanscom Airfield is very important for a suite of birds that require early succes-

sional habitats. Two state-listed grassland obligates, upland sandpiper and grasshopper sparrow, nest in the large expanses of mowed grass at the airfield, as do various other grassland birds such as savannah sparrow, bobolink, and eastern meadowlark. One or two pairs of American kestrels, a cavity-nesting, grassland species whose population throughout the Northeast is in sharp decline, nest in crevices and cavities in the hangars and other buildings at the airfield. During migration and in winter this artificial grassland occasionally hosts other open country species including snowy and short-eared owls, northern harrier, horned lark, Lapland longspur, and snow bunting. Much of the Massport land around the margins of the airfield is maintained as shrubland habitat which supports species such as brown thrasher, blue-winged and prairie warblers, eastern towhee, field sparrow, and indigo bunting.

Reptiles: The common garter, northern water, ribbon, milk, northern ring-neck, eastern racer, and DeKay's snakes have all been seen in Concord, though only garter and water snakes remain common. The Massport land near Hanscom Airfield supports a small population of eastern racers, a declining species that may be a candidate for state listing in the future. All but one of the inland species of turtles in Massachusetts can still be found in Concord, though only painted and snapping turtles are common. Musk turtles are scattered along the major rivers and Nashoba Brook, though their numbers are small. Spotted turtles (Species of Greatest Conservation Need) occur in several areas in Concord, especially within the Estabrook Woods area, though their numbers have declined significantly in recent decades. Among the truly rare species, a small population of wood turtles (Species of Special Concern) persists on Massport land adjacent to Hanscom, a few individual eastern box turtles (Species of Special Concern) have been found in recent years in the Bedford Levels section of town, the Great Meadows area, including town-owned and private lands adjacent to the National Wildlife Refuge supports one of the largest populations of the threatened Blanding's turtle in the northeastern United States. Introduced red-eared slider turtles are present and are breeding in Concord, especially in and near Great Meadows and a large adult false map turtle, another introduced species, was recently found in that area by Bryan Windmiller.

Amphibians: Green frogs, bullfrogs, wood frogs, pick-erel frogs, spring peepers, and gray frogs remain common and widespread in Concord. The Great Meadows area and Concord River wetlands support

what may be the Commonwealth's largest remaining population of northern leopard frog, a species that declined dramatically throughout its continent-wide range in recent decades. Spotted and red-back salamanders are common in the Town, while eastern newts and northern two-lined salamanders occupy a few areas of suitable habitat. Two rare salamander species, the four-toed salamander (Species of Greatest Conservation Need) and the state-listed blue-spotted salamander (Species of Special Concern) occur in several areas within the Town.

Vernal pools, bodies of standing water that dry up occasionally and thus lack fish populations, are particularly important breeding sites for many amphibian species. Concord is rich in vernal pools. Windmillers sampled more than 80 vernal pools in Concord and measured the abundance of spotted salamander egg masses as well as the presence of other amphibian species.⁷¹ Most spotted salamanders bred in a few large ponds. Also of land protection importance, the area, integrity, and habitat characteristics of upland forest within 300 meters of breeding ponds were the most significant correlates with spotted salamander abundance.

Fish: Fish diversity is moderately high in Concord, with many native and introduced species found throughout the rivers and stillwater habitats of the town. Native brook trout persist in Jennie Dugan Brook and have been found in Second Division Brook at the Concord-Sudbury line. The rivers and major ponds harbor a diverse mix of warm water fish fauna, most of them introduced. Among the notable populations of introduced fish are largemouth and smallmouth bass, yellow perch, bluegills, and northern pike. The Division of Fisheries and Wildlife stocks selected Concord waters with rainbow trout, brown trout, tiger trout, and occasionally eastern brook trout.

Invertebrates: Concord also supports a wealth of invertebrate species, especially insects. Most of this diversity is poorly known and poorly studied, though insects comprised the largest group of organisms of the 1,905 species found in Concord during the first biodiversity day in 1998.

One group of insects that is fairly well studied in Concord is the butterflies. The Concord Annual Butterfly Count conducted in association with the Massachusetts Butterfly Club was begun in 1989 and celebrated its 25th anniversary in 2013.

Over the last quarter century nearly 70 different species of butterflies have been seen with an annual average of approximately 40 species. Common butterflies



Monarch on Butterfly Bush by Ryan Schain

such as eastern tiger swallowtail, American copper, eastern tailed blue, American lady and silver-spotted skipper are seen nearly every year. The harvester Acadian hairstreak, Milbert's tortoiseshell and cross-line skipper are examples of uncommon to rare butterflies that have been seen. One of the Concord count's specialties is the bronze copper. Uncommon to rare in other parts of the state, Concord is fortunate to have several colonies of these butterflies inhabiting wetland edges on the Sudbury River. Occasional studies have also been undertaken of several other insects groups in Concord, including dragonflies and damselflies and some of the beetle species, particularly tiger beetles.

Rare Species: In 2010, the Massachusetts Division of Fisheries & Wildlife's Natural Heritage and Endangered Species Program (NHESP) published a statewide *BioMap2*, showing "core habitats" with a concentration of rare natural communities, animals, and/or plants. *BioMap2* lists 16 Massachusetts Endangered Species Act-listed species and 7 Non-listed Species of Conservation Concern in Concord. *BioMap2*: Core Habitat in Concord covers 5,403 acres, 2,926 acres of which are protected. Additionally, *BioMap2* identifies 3,738 acres of Critical Natural Landscape in Concord, 2,665 acres of which are protected. Core Habitats in Concord include: three Exemplary or Priority Natural Community Cores, one Forest Core, nine Wetland Cores, twelve Aquatic Cores, and eleven Species of Conservation Concern Cores (eight birds, one reptile, three amphibians, four insects, three mussels, ten plants). Critical Natural Landscapes include one landscape block, four wetland core buffers, and nine aquatic core buffers.

Species of Conservation Concern, Priority and Exemplary Natural Communities and Other Elements of Biodiversity in Concord

[Source: BioMap2: *Conserving the Biodiversity of MA in a Changing World*]

Mussels

Triangle floater, (*Alasmidonta undulata*), Non-listed SWAP species
Eastern pondmussel, (*Ligumia nasuta*), SC
Creeper, (*Strophitus undulatus*), SC

Insects

Moths

Two-striped cord grass moth, (*Macrochilo bivittata*), Non-listed SWAP

Butterflies

Frosted elfin, (*Callophrys irus*), SC

Dragonflies

Arrow clubtail, (*Stylurus spiniceps*), Non-listed SWAP species
Umb shadowdragon, (*Neurocordulia obsoleta*), SC

Amphibians

Four-toed salamander, (*Hemidactylium scutatum*), Non-listed SWAP

Northern leopard frog, (*Rana pipiens*), Non-listed SWAP

Blue-spotted salamander, (*Ambystoma latera/e*), SC

Reptiles

Blanding's turtle, (*Emydoidea blandingii*), T

Birds

Upland sandpiper, (*Bartramia longicauda*), E

American bittern, (*Botaurus lentiginosus*), E

Least bittern, (*Ixobrychus exilis*), E

Pied-billed grebe, (*Podilymbus podiceps*), E

Sora, (*Porzana carolina*), Non-listed SWAP

Common moorhen, (*Gallinula chloropus*), SC

Grasshopper sparrow, (*Ammodramus savannarum*), T

King rail, (*Rallus elegans*), T

Plants

Acadian quillwort, (*Isoetes acadiensis*), E

Violet wood-sorrel (*Oxalis violacea*), E

Pod-grass, (*Scheuchzeria palustris*), E

Lake quillwort (*Isoetes lacustris*), E

River bulrush, (*Bolboschoenus fluviatilis*), recently de-listed

Climbing fern, (*Lygodium palmatum*), SC

Long's bulrush, (*Scirpus longii*), T

Britton's violet, (*Viola brittoniana*), T

Engelmann's umbrella-sedge, (*Cyperus engelmannii*), T

Resupinate bladderwort, (*Utricularia resupinata*), T

Priority Natural Communities

Small-river floodplain forest, 52

Kettlehole wet meadow, 53

E = Endangered

T =Threatened

SC = Special Concern

SWAP = State Wildlife Action Plan

51 =Critically Imperiled communities, typically 5 or fewer documented sites or very few remaining acres in the state.

52 =Imperiled communities, typically 6-20 sites or few remaining acres in the state.

53 =Vulnerable communities, typically have 21-100 sites or limited acreage across the state.

Unique Features

Concord has a wealth of unique cultural, recreational, and ecological features that need to be protected in order to maintain Concord's character.



Farmland is a key component of Concord's character, by Cherrie Corey

Scenic Sites

1. Historic Districts
 - a. American Mile
 - b. Barrett Farm
 - c. Church Street
 - d. Hubbardville
 - e. Main Street
 - f. North Bridge/Monument Square
2. From high point
 - a. Fairhaven Cliff
 - b. Upper Assabet River reach
 - c. Punkatasset Hill
3. Water
 - a. Walden Pond
 - b. Fairhaven Bay
 - c. Great Meadows National Wildlife Refuge
4. Discrete Object
 - a. Waterfall at Nashoba Brook
 - b. Egg Rock from Lowell Road
5. Opening along road
 - a. Spencer Brook Valley from Lowell Road
 - b. Westford Road
6. Large agricultural area
 - a. Monument Street
 - b. Sudbury Road/Route 2/Williams Road
 - c. Sudbury Road/Route 117/ORNAC
 - d. Barrett's Mill Road
 - e. Lexington Road

Carlisle

Bedford

Lincoln

Acton

Sudbury

Maynard

Unique Features

Legend



Scenic Sites

Historic Districts



American Mile



Barrett farm



Church Street



Hubbardville



Main Street



North Bridge/Monument Square



Roads



Heritage Landscape Inventory Farms



National Register of Historic Places



BioMap2 Core Habitat

0 0.25 0.5 1 1.5 Miles



Though no state-listed Areas of Critical Environmental Concern exist in Concord, the Town has 52 state-listed species of conservation interest according to the Natural Heritage Endangered Species Program (NHESP). Some of these are historic records or are species that have not been recorded since the nineteenth century. The list compiled in NHESP's updated *BioMap2* report (2012) gives a current list of the species of concern in Concord today.

Concord has the highest density of documented rare-species records (about 2 per square mile) of any town between Plymouth and the Sturbridge area. The main reasons are probably the confluence of the three rivers and the abundance of early observers studying plants and animals here from the mid-nineteenth to mid-twentieth century. Protecting this well-documented and deeply researched part of New England for all the species, particularly those that are not often seen elsewhere, should be a priority. Very little rare species habitat exists in adjacent towns; only Bedford and Sudbury have appreciable linkages evident in a northerly direction toward New Hampshire, though perhaps the most promising linkage would extend through southern Westford into Groton and beyond. Of the rivers and major streams across the region, only the Sudbury River and Concord/Bedford portion of the Concord River contain significant rare wildlife habitat.

E.2 Good News and Bad News

The good news in all this is the wealth and diversity of Concord's wildlife; the bad news is that there are significant challenges to wildlife conservation in the Town. Key among these are loss of, and fragmentation of, wildlife habitat caused by continuing development and an increase in traffic volume and speed on even small roads. The most significant wildlife barrier is Route 2 which bisects the Town and in most areas has concrete "Jersey barriers" which make passage impossible for most animals. To address this problem four "wildlife tunnels" were built under Route 2, in 2005.

Wildlife Passages: Cameras located in the wildlife underpasses under Route 2 have recorded 32 species utilizing the corridors. These include red fox, gray fox, coyote, fisher, eastern cottontail, white-tailed deer, weasel, ruffed grouse, beaver, salamander, mink, and otter.⁵⁹ A fifth underpass will be constructed to offset the Route 2 widening effects to wildlife.



White-tailed deer using Rt. 2 Wildlife Passage

Another threat to wildlife habitat is the proliferation of invasive plants – many of which supplant traditional wildlife food sources. Phragmites, a tough reed, has replaced cattails in many wetlands and ponds. Water chestnut and Eurasian milfoil have replaced water lilies. Buckthorn, burning bush, Asiatic bittersweet, Japanese knotweed, and swallowwort are just a few of the terrestrial plants flourishing and spreading. Concerned citizens and conservation groups have made valiant efforts to halt the spread of these plants and to remove them where found. The long-term success of these efforts is yet to be determined.

Purple loosestrife, long identified as an invasive plant, arrived in the colonies most likely in ship ballast during the late 1700s. It was initially welcomed as an attractive plant that offered herbal medications and nectar attractive to bees and butterflies. Today it is still prized by bee keepers but botanists are less enthusiastic as loosestrife has taken over many wetlands. Currently an initiative is underway to halt the spread of purple loosestrife by releasing beetles that feed on the plants, an approach that appears to have promising long-term success.

The SuAsCo Cooperative Invasive Species Management Area (CISMA) is a group of partnering organizations that work together to manage and control invasive species in the SuAsCo Watershed. Concord has been involved in regional invasive species control efforts since 2005, and in 2009 was involved in the establishment of the SuAsCo CISMA watershed-wide program. Current projects include early detection and rapid removal of invasive species, beetles releases to control purple loosestrife, and the Sudbury Weed Education and Eradication Team (SWEET) invasive species management project.¹⁸



Conservation Crew harvesting invasive water chestnut in Fairhaven Bay

For more information regarding invasive species and how you can help, visit the Concord Division of Natural Resources website at:

www.concordma.gov/pages/ConcordMA_NaturalResources/invasives/invhome.

Pollution of local waters also stresses wildlife populations – whether it be phosphate runoff from cultivated lawns, pesticides used to kill weeds and invasive plants, or simply discharged pollutants.

Fish in the Sudbury and Concord Rivers have elevated levels of contaminants as a result of pollution from the Nyanza superfund site in Ashland, MA and should never be eaten (see: *Restoration Plan and Environmental Assessment for the Nyanza Chemical Waste Dump Superfund Site*, September 2012).⁵⁴ Phosphorus and nitrogen from sewage treatment plants and development in towns upstream along the Assabet River, as well as from MCI-Concord, enrich the river and reduce oxygen levels. This impacts both fish and aquatic mammals such as beaver, muskrat, otter, and mink. However, recreational fishing remains popular in both rivers and ponds. Fish stocked by the Division of Fisheries and Wildlife are free of these pollutants, at least until they have lived in polluted waters for some time.

One of the most insidious threats to wildlife in Concord is the diversity of human attitudes. What plants or animals do we wish to have and how many is too many? Some residents enjoy plants labeled as “invasive” by others. Deer are considered an asset by some and “too much of a good thing” by others. Coyote families are perceived as threatening by some while others note that they provide a certain amount of small rodent control. The diversity of attitudes among Concord residents will continue to make wildlife conservation in Town both stimulating and challenging.

The following are systematic surveys conducted of species in Concord.

Newbury Woods Ecology. An ecological inventory conducted in 1998 for the Concord Land Conservation Trust of a 55-acre parcel (Newbury Woods) embedded in the southwestern portion of the Estabrook Woods area provided an impressive picture of the value of a large natural area in Concord.⁷² This mainly pine-oak-covered parcel with swamps, hemlock groves, a pond, and an old field supported an exceptional concentration of forest-interior species that are rare in the Concord region. Highlights were porcupines, fishers, barred owls, black-throated green warblers, hermit thrushes, and northern waterthrushes. Other species of considerable interest include great horned owls, blue-winged warblers, several vascular plant species (of the 249 recorded), and two state-listed invertebrates, a bog-breeding dragonfly (ringed boghaunter) and a shrimp-like crustacean (Mystic Valley amphipod). The interior portion of the parcel had a paucity of invasive exotic species. The adjacent Christian family property contained even more state-listed rare species and locally rare species. At a broader scale, the Estabrook Woods is apparently the second largest contiguous forest within 25 miles of Boston (Willowdale State Forest in Ipswich is a bit larger), and these two forests are the only ones with such a dependable array of forest-interior wildlife. The only other fairly large contiguous forest in Concord’s region is the “Desert” (Sudbury-Hudson-Marlborough-Stow) which is partly dissected by military roads and other human activities. In short, the large unfragmented natural areas of Concord, and especially the Estabrook Woods, are of exceptional value in Concord and indeed the Boston Region.

Bigelow Field/Soutter Woods Plants. A plant survey conducted in 1998 for the Concord Land Conservation Trust of a 76-acre protected area (Bigelow Field and Soutter Woods by Sudbury Road, Route 2, and the Sudbury River) provides a quite different picture.¹⁹ This heterogeneous land constituting the eastern portion of the Jennie Dugan Kames large natural area, contains a 12-acre pasture, wet meadow, oak-pine forest, red maple swamp, floodplain marsh, and two vernal pools. The wet meadow is an uncommon habitat in Concord. Many invasive species had considerable coverage and most habitats had prominent invasive species cover. Two hundred and fifty vascular plants were identified, including Atlantic white cedar. Distinctive species included bobolinks and bluebirds in open areas and two state-listed invertebrates (Mystic Valley amphipods and elderberry borer beetles).

Biodiversity Sites. A report for the Massachusetts Executive Office of Energy and Environmental Affairs identified and documented 42 Biodiversity Sites in the Sudbury, Assabet and Concord Rivers Watershed.²⁰ Eight of the 42 outstanding biodiversity sites in this large area are in Concord as follows:

1. **Estabrook Woods:** Extensive area in Concord and Carlisle. Mixed geology, variable oak/white pine forest types with bogs, ponds, streams, small patches of sweet soils, hemlock forest, red maple swamp, shrub swamps, level bogs. One of two largest unfragmented forests in Middlesex County, a variety of habitats, connected to Concord River, well-documented natural history, state-listed rare species, many focal species including unusual forest-interior birds, Louisiana and northern water thrushes, winter wren, black-throated green warbler, porcupine, breeding fisher, bear, state-listed dragonflies.
2. **The Great Meadows:** 250 acres. Both deep and shallow emergent marshes, wet meadows, shrub swamps, small river-floodplain forest, alluvial red maple swamp. The core of the area is a National Wildlife Refuge and Wild and Scenic River with more or less natural flow and flood dynamics, extensive marshes and floodplain forest, other associated wetland communities (some unique to SuAs-Co), many NHESP (state) records for amphibians/reptiles, birds and plants, migratory waterfowl and passerine birds, many focal species, and an ownership mandate to protect biodiversity.
3. **Balls Hill:** 230 acres (immediately west of Great Meadows and the Concord River). Bluff over Concord River and impounded ponds, steep upland directly abuts river. Unusual geology, high number of focal species and endangered species, NHESP species records, provides upland directly adjacent to river corridor.
4. **Egg Rock:** 205 acres. Small river floodplain forest, linden/hop hornbeam stand. Confluence of two mainstem rivers that flood regularly, good example of floodplain forest, unusual upland trees.
5. **Minute Man Grasslands.** 780 acres (partly in Lincoln). Cultural grasslands. Extensive successional forest areas are in the process of being cleared to become fields managed for grassland birds, the Minute Man National Historical Park fields are near other fields owned by Lincoln Conservation Commission, both field complexes have ownership man-

dates to manage for biodiversity.

6. **Greater Walden:** 1,250 acres (partly in Lincoln). Mixed oak/white pine forest on glacial outwash, tracts of mature forest with extensive hemlock, kettlehole pond, kettlehole level bogs, streams, fields, acidic rock outcrop. Mosaic of habitats including Walden Pond, good examples of kettlehole bogs, mixed-age forest types adjacent to Sudbury River, floodplain forest in northern section, interior-forest focal species.
7. **Jennie Dugan Kames:** 410 acres. Vernal pool, level bog, fen, mixed forest, glacial kames. Unusual diversity of species especially for small area, includes exceptionally rich vernal pool that is similar to coastal pond, brook with trout and banded sunfish, wetlands with breeding soras, woodlands with hermit thrush, winter wren, black-throated green warbler and porcupine.
8. **Second Division Brook.** 390 acres. Shrub swamp, grassland, streams, oak forest, white pine forest. Unusual combination of swamp, streams, grassland, and steep slopes on glacial kames; NHESP rare plants; sub-basin divide.

The preceding surveys and data make apparent that no systematic mechanism exists for keeping track of species in Town. Species of importance include state-listed rare animals and plants, pests and invasives, and certain mammals, birds, reptiles, amphibians, fish, butterflies, plants, and other species appreciated by residents and society. Thus it is difficult for municipal agencies to gather and use key wildlife and biodiversity information in a timely manner.

A wildlife and biodiversity committee reporting to Concord's Natural Resources Commission (NRC) and coordinating with the Natural Resources Director should be established, both to help protect key species and to aid the Town in its planning and management. Members of the committee should gather and maintain systematic data on key species and natural communities in Concord and its region; assist the Town and NRC by providing wildlife and biodiversity information to aid in planning and management; and help inform the Town and its residents about wildlife, biodiversity, and land protection in the Concord region.

E.3 Corridors for Wildlife Migration

Major wildlife corridors are conduits for the movement of species through and between towns. They prevent isolation of patches and the gradual species impoverishment therein. Species often disappear temporarily in a local area and corridors may enhance their return. Corridors provide protective cover for wildlife against human activities and domestic animals. The network of corridors provides options for species movement to avoid disturbances, hunters, and predators.

The distribution of large natural vegetation areas helps determine the location of major wildlife corridors. Wildlife corridors contain at least a high shrub layer, typically without significant gaps or narrows. They normally connect with large patches of natural vegetation and interconnect to form a town-wide network with loops. The wildlife corridors in Concord extend to the town boundary and connect to large patches of natural vegetation in the surrounding towns. Water protection corridors, especially if wider than the frequently flooded portion of a floodplain, are part of the wildlife network.

Major wildlife and water-protection corridors:

- C1. Assabet River
- C2. Sudbury River
- C3. Concord River
- C4. Saw Mill Brook
- C5. Spencer Brook
- C6. Second Division Brook
- C7. Jennie Dugan Brook
- C8. Second Division Brook / Jennie Dugan Kames to Assabet River
- C9. Virginia Road Woods Area to Walden Woods / Town Forest
- C10. Town Forest to Walden Reservation via railroad underpass and school land
- C11. Nashoba Brook / Warner's Pond
- C12. Annursnac Hill / Strawberry Hill Road Area to Estabrook Woods Area
- C13. Virginia Road Woods to Great Meadows / Ball's Hill Area

Wildlife corridors can be as large as the Concord River floodplain and as small as a hedgerow running between farm fields. For the purpose of this plan, only the medium-to-large corridors are mapped (see Open Space Framework Map). Migratory birds, river otters and Blanding's turtles have been observed to move along local river valleys. For many of the other corridors listed above, local data on wildlife move-

ment are lacking, but studies of similar corridors elsewhere confirm movement of diverse species. Undeveloped, naturally vegetated corridors connecting large open-space areas in town are gradually being severed, and the opportunity to preserve the continuity of these corridors is disappearing.

On a broader scale, Concord and its region are connected to New Hampshire through a patchwork corridor of large natural areas, which serves as a source of large wildlife, such as moose, bear, and potentially cougar. Only one route or wildlife corridor from southern New Hampshire appears promising for effectiveness in the long term. This passes through Pepperell/Townsend and Groton into Westford, and then under/over Interstate 495 into northern Acton and/or Carlisle before reaching Concord and many other towns of the region. Thus, to maintain the wildlife corridor against the noose of development to the northwest requires serious collaborative land protection, especially in Westford and Groton, but also in towns to the southeast and northwest (see Regional Context Map).¹¹

Protecting this corridor extending north to New Hampshire would provide for sustained biodiversity and wildlife movement within Concord, and throughout its region as a whole; a growing concern in light of the potential necessity for species to move in response to a changing climate. The alternative is an erosion of Concord's rich ecological systems, as rapidly spreading development closes the noose, leaving the Town and its region in isolated pieces.

F) Scenic Resources and Unique Environments

Because these resources and environments contribute strongly to the landscape and special character of the community, this subject is mainly integrated into the discussion in *Section 4B*. A Scenic Landscape Inventory survey by the Massachusetts Department of Conservation and Recreation was done in 2006 (revised in March 2007) and results are included in the *Concord Reconnaissance Report: Freedom's Way Landscape Inventory* as part of the Massachusetts Heritage Landscape Inventory Program. Priority heritage landscapes identified in Concord include: Barrett Farm, Estabrook Woods, Flood Meadows, Massachusetts Department of Correction Land, Nine Acre Corner, Virginia Road, Walden Woods / Route 126 Corridor, and West

Concord Village (see Unique Features Map).^{44, 47}

The Unique Features Map on page 51 includes historic places on the National Register, including Walden Pond and lands under the National Park Service, local historic districts, where house modifications are reviewed to maintain the historical character of Concord, as well as agrarian landscapes and areas with high biodiversity, such as the Great Meadows Wildlife Refuge and Estabrook Woods. Though there are no Areas of Critical Environmental Concern in Town, a significant portion of Concord is designated by Bio-Map2 as Core Habitat. Most of these areas are permanently protected, in whole or in part. Unprotected areas within these identified areas are high priority for protection. There are three areas of geological interest identified: Fairhaven Cliffs, the upper Assabet River, and Punkatasset Hill. Additional areas of interest are listed and mapped and described in Section 5. Numerous archeological sites also exist in Town, but in order to protect these resources their locations are not made public.³⁷

G) Environmental Challenges

Global climate models indicate a high likelihood of changes in New England in the decades immediately ahead.^{21, 2, 51} Less extreme low winter temperatures, less snowfall, and less snow cover are likely. Warmer surface water affecting water supply, fish, and recreation can be expected. An increase in rainfall and in the variability of precipitation is likely, suggesting somewhat wetter conditions favoring disease vectors, water contaminants, and heavy precipitation events.⁷⁰

Though beneficial in many ways, agriculture presents its own challenges when viewed in the context of impacts to local wildlife, habitats, and water resources. Conventional farming methods can lead to soil erosion and often require high amounts of pesticide and nitrates, both leading causes of groundwater contamination. Inefficient irrigation systems can affect water

security. Fences fragment habitat and can be dangerous for certain species. Livestock have the potential to over-graze and also impact water supply through fecal waste if not properly managed.³⁸ Fortunately, Concord farms are managed responsibly to minimize negative impacts on the environment.

Within the Town, based upon responses to the questionnaire, excessive development is considered to be the major environmental challenge influencing open space and recreation planning. Much of the current building in Town involves reconstructing existing houses; however, most new construction on undeveloped land involves multi-unit projects. These developments usually incorporate an open space component, resulting in small pockets of open space distributed throughout Town.

At the town scale, erosion and sedimentation are negligible and chronic flooding in flood-prone areas is normal, but still poses significant threats (see discussion earlier in this section).

Concord's landfill, which was opened in 1959, was capped in 1995 and obtained DEP closure status in 2012. This land is now used for snow storage, composting of brush and leaf litter, and a new solar array.

The Town is working with the EPA to develop a Remedial Investigation and Feasibility Study for the cleanup of the chemical-pollutant site Nuclear Metals (Starmet). A draft of this study is under review by the EPA. The Town's desire is for EPA to select a remediation alternative that meets residential standards and allows for the least restricted future use of the site.

The following is a summary of EPA's Waterbody Assessment and Total Maximum Daily Load Status for Concord's Waterbodies (see map and additional information on the following pages).



Ringed-necked ducks by Ryan Schain

Environmental Challenges

Oil and/or Hazardous Materials Sites

Tier 1A: Most complex and hazardous sites. Require direct oversight by Massachusetts Department of Environmental Protection. Sites that pose an imminent hazard or affect public water supplies are automatically classified as Tier 1A.

Tier 1B: Slightly less complex and contaminated than Tier 1A. Permit required.

Tier 1C: Slightly less complex and contaminated than Tier 1B. Permit required.

Tier 1D: Required information has not been submitted to the Massachusetts Department of Environmental Protection on time.

Tier II: Least contaminated, complicated, and potential for exposure. No permit required.

Activity and Use Limitation Sites

An AUL provides notice of oil and/or hazardous material contamination remaining at the location after cleanup has been conducted. The AUL is a legal document that identifies activities and uses of the property that may and may not occur, as well as the property owner's obligation and maintenance conditions that must be followed to ensure the safe use of the property.

The AUL sites in Concord are in close proximity to the major rivers running through Town. Therefore, they may have negative impacts on the water quality of these rivers. Efforts should be made to reduce the risks of oil and/or hazardous material contamination in the future.

Impaired Rivers and Lakes

Surface waters in Massachusetts are evaluated with respect to their capacity to support aquatic life, fish consumption, drinking water, shellfish harvesting, primary contact-recreation (i.e. swimming), secondary contact-recreation (i.e. boating), and aesthetics. Surface waters are categorized as 1-5 depending on their ability to support these uses:

1. Attaining all designated uses.
2. Attaining some of the designated uses and insufficient or no data is available to determine if remaining uses are attained.
3. Insufficient or no data to determine if any designated uses are attained.
4. (A + C) Impaired for one or more designated uses by low flow, habitat alterations, or non-native species.
5. Impaired for one or more designated uses by pollutants such as nutrients, metals, pesticides, solids, or pathogens.

Concord's Waterbodies

- *Assabet River*: Category 5 for nutrients, organic enrichment/low dissolved oxygen, and pathogens
- *Bateman's Pond*: Category 4c
- *Concord River*: Category 5 for exotic species, metals, nutrients, and pathogens
- *Elm Brook*: Category 5 for pathogens, turbidity, and other habitat alterations
- *Fort Pond Brook*: Category 3
- *Great Meadow Pond #3*: Category 4c
- *Mill Brook*: Category 4c
- *Nashoba Brook*: Category 4c
- *North Great Meadows*: Category 4c
- *Second Division Brook*: Category 3
- *Spencer Brook 1*: Category 3
- *Sudbury River*: Category 5 for exotic species and metals
- *Spencer Brook 2*: Category 2
- *Walden Pond*: Category 4a for mercury
- *Warner's Pond*: Category 4c for exotic species and mercury
- *White Pond*: Category 3

